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Technical Evaluation of Moving C-130 Engine Compressor Wash Operations Indoor Washrack, Building 228, Little Rock Air Force Base, Arkansas

Franz J. Schmidt, Captain, USAF
Doris A. Hemenway, Master Sergeant, USAF
Robert P. Davis, Staff Sergeant, USAF

October 1996

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Occupational and Environmental Health Directorate
Bioenvironmental Engineering Division
2402 E Drive
Brooks Air Force Base TX 78235-5114

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FRANZ J SCHMIDT, Capt, USAF, BSC
Chief, Water Quality Branch

JAMES D. MONTOMERY, Lt Col, USAF, BSC
Chief, Bioenvironmental Engineering Division

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Captian Franz J. Schmidt
MSgt Doris A. Hemenway
SSgt Robert P. Davis

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Armstrong Laboratory
Occupational and Environmental Health Directorate
Bioenvironmental Engineering Division
2402 E Drive
Brooks Air Force Base TX 78235-5114

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Personnel from the Armstrong Laboratory Water Quality Branch conducted Wastewater Charaterization on the wastewater from a C-130 Engine Compressor Wash Operation at Little Rock AFB, Arkansas, from 23 Jan 95 to 27 Jan 95. Based on the Cadmium and Nickel Mass Balance Models, the scope of the survey was to compare the models with the actual amount of cadmium and nickel in the engine compressor washwater from the point where the washwater fell from the C-130 aircraft to Little Rock AFB's wastewater discharge point.

The combined results of the phased investigation led to our recommendations that the base could conduct compressor washes on up to two or three aircraft per day without pretreatment. We recommended that the base carefully monitor and maintain the oil water/separator at Facility 228 as long as compressor washes would be conducted there, to ensure that non-compliance would not result from cadmium in the separator from past operations being released into the sanitary sewer system in subsequent operations, resulting in a slug of heavy metals that could cause a violation of pretreatment agreement limits. Additionally, we recommended that if compressor washes were to be conducted for a long time period, the base should consider an industrial wastewater pretreatment system for heavy metals generated from the operations.

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INTRODUCTION

Compressor wash water from the T-56 engine in the C-130 aircraft has been shown to contain cadmium in concentrations from less than one milligram per liter (mg/L) to over 80 mg/L, measured as total recoverable cadmium. Standard compressor wash procedures allow the wash and rinse water from the operation to fall to the tarmac where the engine is washed, with runoff eventually entering the base storm drainage system. Headquarters Air Combat Command recognized the Clean Water Act (CWA) and Resource Conservation and Recovery Act (RCRA) compliance implications with this wastewater, and has initiated a program to find solutions to manage this waste in an appropriate manner. Little Rock AFB has identified an alternative to flightline compressor washing, which is to perform the compressor washing operation at an indoor washrack that collects the wastewater and discharges through an oil/water separator into the sanitary sewer. Little Rock AFB has a pretreatment agreement with the City of Jacksonville, Arkansas, which treats all sanitary sewage from the base. Little Rock AFB requested that Armstrong Laboratory Occupational and Environmental Health Directorate, Bioenvironmental Engineering Division (AL/OEB) perform a study to determine whether introduction of the new waste stream to the sanitary sewer would cause the base to exceed their pretreatment agreement limit for cadmium (0.366 pounds of cadmium per day).

Little Rock AFB, in the summer of 1994, stopped periodic compressor washes under a temporary waiver from San Antonio Air Logistics Center, Kelly AFB. The waiver allowed the base to discontinue the washes until 1 January 95 in order to develop a means to manage the wastewater in compliance with the Clean Water Act and RCRA. The base planned to resume C-130 compressor washes in January 1995 based on the findings of the Armstrong Laboratory studies.

The Armstrong Laboratory Water Quality Branch, using funding provided by HQ ACC/CEVCM, evaluated the effects of moving the compressor wash operation to the indoor washrack in a three-phased study. Phase I consisted of a mass balance study, estimating cadmium loading to the sanitary sewer system based on available analytical data for the compressor wash wastewater and compliance monitoring data from the base sanitary sewer system. Phase II consisted of a site inspection and tracer study. The purpose of Phase II was to verify physical connections within the sewer system and estimate the behavior of cadmium in the collection system. Phase III consisted of an actual indoor engine compressor wash, with sampling of the wastewater and the base sanitary sewer system to verify the findings of Phase I and II and to quantify the retention of cadmium in the oil/water separator at Facility 228 and the lift station at Facility 270.

This technical report presents the findings of our mass balance and surrogate tracer studies (Phases I and II), and also presents the findings of the work performed under Phase III of this effort.

DISCUSSION

Phase I: Mass Balance Exercise for Cadmium

Scope

The Little Rock AFB pretreatment agreement with the City of Jacksonville allows the base to discharge a maximum of 0.366 pounds of cadmium per day in base sewage. Compliance with this standard is determined by semiannual sampling, using a 24-hour, flow-weighted, composite sample made up of 48 subsamples. Samples are collected by the base Bioenvironmental Engineering shop at the monitoring point for Little Rock AFB in Jacksonville. Flow measurements for mass calculation are based on the flow readings at the flume where the samples are collected. The mass balance exercise estimated quantities of cadmium that could be expected in the base effluent by varying the factors of number of planes washed, concentration of cadmium in the wastewater, volume of wastewater, concentration of cadmium in the base sewer system from other sources, and discharge from the base sewer system.

Methodology

We used a Microsoft Excel spreadsheet to model the factors described above. The model was set up with the following variables and equations:

A	B	C	D	E	F	G	H	I	J
No. Aircraft washed per day	Wash water Cd conc. (mg/L)	Wash water volume (gal)	Rinse water Cd conc. (mg/L)	Rinse water volume (gal)	Cd load from engine wash (lbs/day)	Cd conc. in sewer (mg/L)	Sewer dis-charge (gal/day)	Sewer Cd loading (lbs/day)	TOTAL Cd load (lbs/day)
User input	User input	User input	User input	User input	Equation No. 1	User input	User input	Equation No. 2	F + I

Figure 1: Modeling Equation Variables

Equation No. 1:

Cd loading from
engine wash (lbs/day):

$$F = \#\text{ aircraft washed} \times 4 \frac{\text{engines}}{\text{aircraft}} \times [(8.34 \times 10^{-6} \times B \times C) + (8.34 \times 10^{-6} \times D \times E)]$$

Equation No. 2:

Sewer Cd loading (lbs/day):

$$I = 8.34 \times 10^{-6} \times G \times H$$

[Note: lbs/gal = mg/L X 0.001 g/mg X 3.785 L/gal X 0.0022046 lb/g = 8.34×10^{-6}]

* * * * *

One important note regarding this model is that it assumes that all the cadmium which enters the sewer will travel unimpeded off base to the Jacksonville treatment works. This assumption is known to be invalid, although at this time we do not know to what extent cadmium from the compressor wash operations will be impeded or retained by the pretreatment devices and other parts of the sewage collection system. Implications of this faulty assumption will be addressed in the discussion section of this report, but in any case the model will invariably overestimate the amount of cadmium reaching the compliance monitoring point for any set of conditions modeled. This error increases the safety factor for the base. Some of the later scenarios modeled take this factor into account by assuming various percentages are retained in the collection system. The third phase of this study, the actual wash of an aircraft at Facility 228, enabled us to quantify cadmium retention/detention to some degree.

We used the following values to represent typical conditions for modeling:

Factor	Value (Source)
Average Cd Concentration, Wash Water	24.3 mg/L (1)
Average Cd Concentration, Rinse Water	11.1 mg/L (1)
Max Cd Concentration, Wash Water	82 mg/L (1)
Max Cd Concentration, Rinse Water	30 mg/L (1)
Volume of Wash & Rinse Water	40 gal (1, base personnel)
Typical Cd Concentration, Base Sewer	0.00425 mg/L (base compliance data)
Max Cd Concentration, Base Sewer	0.0098 mg/L (base compliance data)
Typical Flow, Base Sewer	1.4 MGD (base compliance data)
High Flow, Base Sewer	2.4 MGD (base compliance data)

Figure 2: Modeling Conditions

Source 1: AL/OE-TR-1995-0010, Evaluation of C-130 Compressor Washing Operations Health Assessment, Little Rock AFB, Arkansas

Results

TABLE 1: VARIOUS SCENARIOS CADMIUM LOADING PREDICTION

Table 1 shows the predicted cadmium loading for various scenarios

# Aircraft Washed	Washwate Cd Conc. (mg/L)	Volume of Washwate (gal)	Rinsewate Cd Conc. (mg/L)	Volume of Rinsewater (gal)	**Cd loading fr. operation (lbs/day)**	Cd conc in sewer (mg/L)	Sewer discharg (gal/day)	**Sewer Cd loading (lbs/day)**	**TOTAL Cd load (lbs/day)**
1 - Per aircraft, avg cadmium concentrations from AL/OEM study, 35 gal wash, 5 gal rinse, avg base effluent data									
1	24.3	35	11.1	5	**0.0302**	0.0043	1400000	**0.0496**	**0.0798**
2 - Same as case number 1 above; but 6 aircraft washed									
6	24.3	35	11.1	5	**0.1813**	0.0043	1400000	**0.0496**	**0.2310**
3 - Absolute worst case Cadmium results, per aircraft, avg base effluent data									
1	82	35	30	5	**0.1007**	0.0043	1400000	**0.0496**	**0.1504**
4 - Absolute worst case Cadmium results, two aircraft, avg base effluent data									
2	82	35	30	5	**0.2015**	0.0043	1400000	**0.0496**	**0.2511**
5 - Worst case Cd, worst case base effluent									
1	82	35	30	5	**0.1007**	0.0098	1961000	**0.1603**	**0.2610**
2	82	35	30	5	**0.2015**	0.0098	1961000	**0.1603**	**0.3618**
6 - Average Cd results, combined with worst case sewer cadmium (Jan 93)									
1	24.3	35	11.1	5	**0.0302**	0.0098	1961000	**0.1603**	**0.1905**
3	24.3	35	11.1	5	**0.0907**	0.0098	1961000	**0.1603**	**0.2509**
5	24.3	35	11.1	5	**0.1511**	0.0098	1961000	**0.1603**	**0.3114**
7 - Worst case, assume half of Cd is trapped									
1	41	35	15	5	**0.0504**	0.0098	1961000	**0.1603**	**0.2107**
3	41	35	15	5	**0.1511**	0.0098	1961000	**0.1603**	**0.3114**
4	41	35	15	5	**0.2015**	0.0098	1961000	**0.1603**	**0.3618**

TABLE 1: VARIOUS SCENARIOS CADMIUM LOADING PREDICTION (CONTINUED)

# Aircraft Washed	Washwate Cd Conc. (mg/L)	Volume of Washwate (gal)	Rinsewate Cd Conc. (mg/L)	Volume of Rinsewater (gal)	**Cd loading fr. operation (lbs/day)**	Cd conc in sewer (mg/L)	Sewer discharge (gal/day)	**Sewer Cd loading (lbs/day)**	**TOTAL Cd load (lbs/day)**
8 - Average case for waste, worst base effluent, assume half of Cd is trapped									
1	12.15	35	5.55	5	**0.0151**	0.0098	1961000	**0.1603**	**0.1754**
4	12.15	35	5.55	5	**0.0604**	0.0098	1961000	**0.1603**	**0.2207**
5	12.15	35	5.55	5	**0.0756**	0.0098	1961000	**0.1603**	**0.2358**
9 - Worst case for waste, average base effluent, assume half of Cd is trapped									
1	41	35	15	5	**0.0504**	0.0043	1400000	**0.0496**	**0.1000**
4	41	35	15	5	**0.2015**	0.0043	1400000	**0.0496**	**0.2511**
5	41	35	15	5	**0.2519**	0.0043	1400000	**0.0496**	**0.3015**
10 - Worst case for waste, variable base effluent, assume half of Cd is trapped									
1	41	35	15	5	**0.0504**	0.01	1500000	**0.1251**	**0.1755**
2	41	35	15	5	**0.1007**	0.01	1500000	**0.1251**	**0.2258**
11 - Worst case for waste, variable base effluent, assume 20% of Cd is trapped									
1	65.6	35	24	5	**0.0806**	0.01	1500000	**0.1251**	**0.2057**
2	65.6	35	24	5	**0.1612**	0.01	1500000	**0.1251**	**0.2863**
3	65.6	35	24	5	**0.2418**	0.01	1500000	**0.1251**	**0.3669**

Conversion factors u	*Formulas used:*
4 engines/aircraft	lb/gal = mg/L X 0.001 g/mg X 3.785 L/gal X 0.0022046 lb/g = 8.34 X 10-6
0.0022046 lbs/g	Cd Loading from operation = # aircraft washed X 4 eng/aircraft X ((8.34 EXP-6 X Cd conc. of
0.26417 gal/L	washwater X vol. washwater) + (8.34 EXP-6 X Cd conc. rinsewater X vol. rinsewater))
1000 mg/g	Cd loading of sewer = 8.34 EXP-6 X Cd conc. in sewer X discharge
8.336 lb/gal water	Total Cd Loading = Cd loading from operation + Cd loading of sewer

Discussion

The following is a discussion of each of the scenarios presented, including the realism, safety factors, and cautions associated with each.

Case 1: This scenario uses the average washwater and rinsewater cadmium concentrations determined in the AL/OE-TR-1995-0010. We used a figure of 40 gallons of water flushed through the engine gas path based on discussions with base personnel. Our breakdown of 35 gallons wash, five gallons rinse is somewhat arbitrary, but is believed to be conservative. This assumes that one-eighth of the total water used is for the rinse. If this figure is higher, then the cadmium loading to the sewer predicted by the model will be higher than that in actual operations. With one aircraft washed per day, 0.03 pounds of cadmium would be released to the sanitary sewer system. This scenario also uses average cadmium concentrations found in the base sewer system determined from compliance data from January 1992 to September 1994 (Figure 1), and average flow data from November 1993 to October 1994 (Figure 2). Based on this average case scenario, with one plane washed per day, cadmium loading at the compliance point would be about 0.08 pounds per day. This is within the range of values of compliance samples collected since 1992, and is well below the compliance limit of 0.366 pounds per day of cadmium. While this case represents a typical, expected compliance sample result, it does not account for situations where combinations of factors can lead to higher results.

Date	Flow (MGD	Cd Load (lbs/day)	Cd Conc (mg/L)
Jan-92	1.425	0.05	0.0042
Jun-92	1.464	0.05	0.0041
Jan-93	1.961	0.16	0.0098
Jul-93	0.91	0.03	0.0039
Jun-94	0.955	0.0175	0.0022
Sep-94	1.115	0.0121	0.0013
Average:	1.305	0.0533	0.00425

Figure 3: Average Cadmium Concentration In Base Sewer System

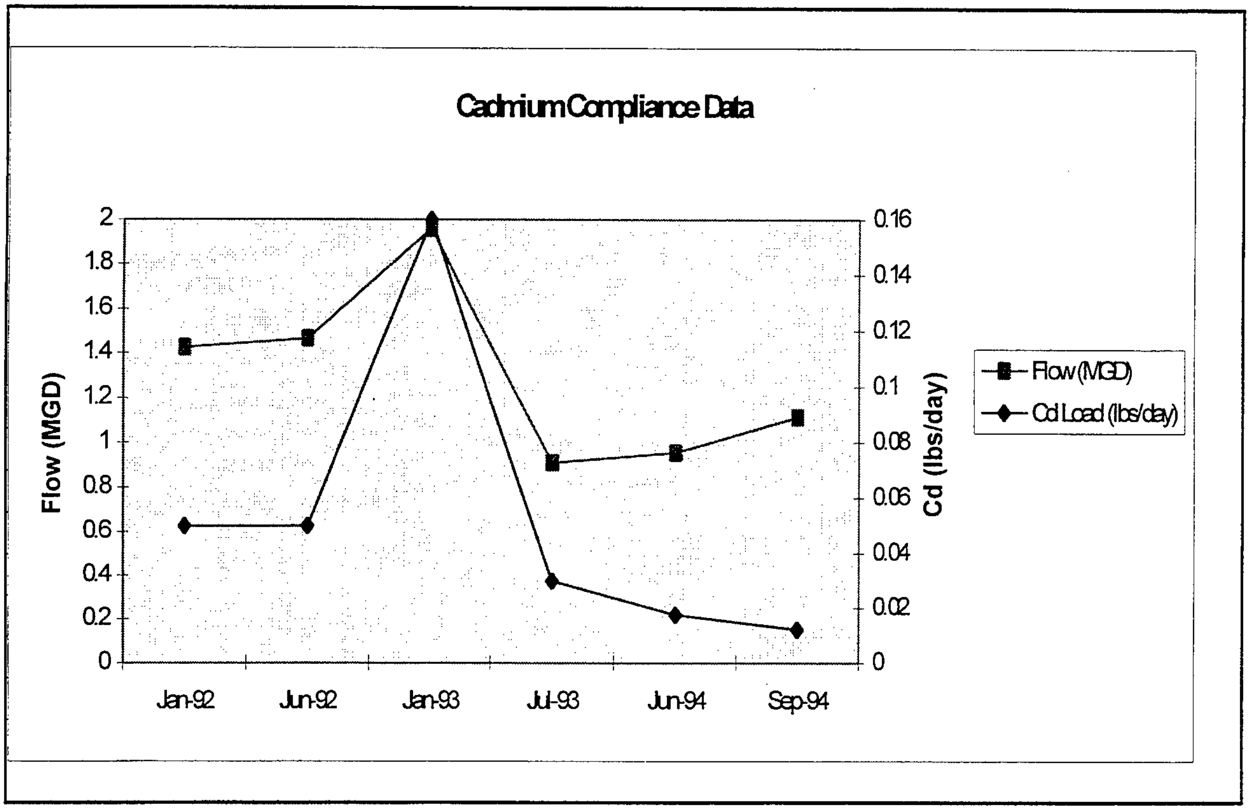


Figure 3A: Cadmium Compliance Data Chart

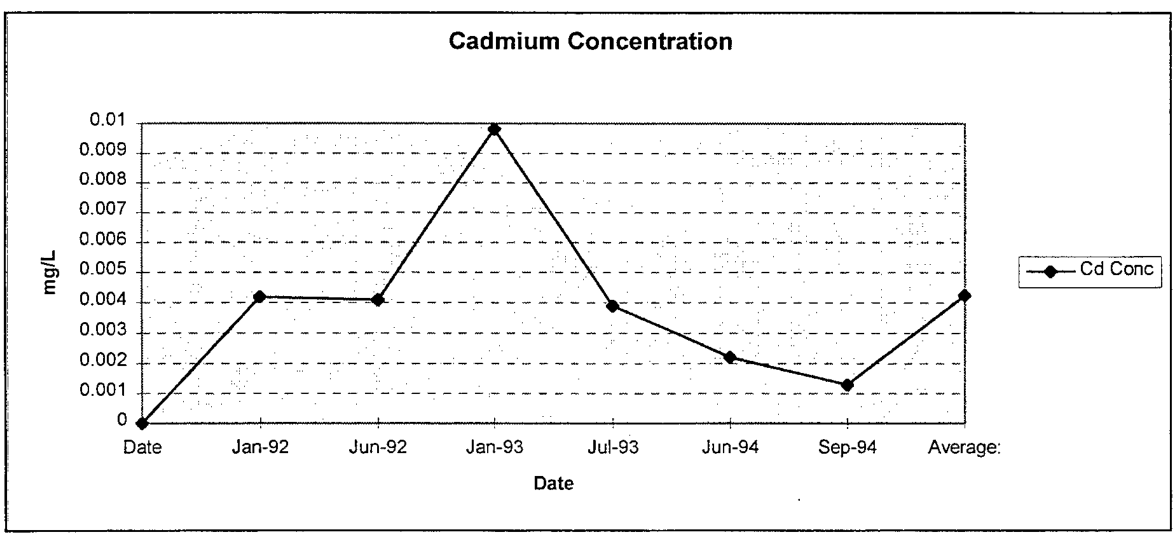
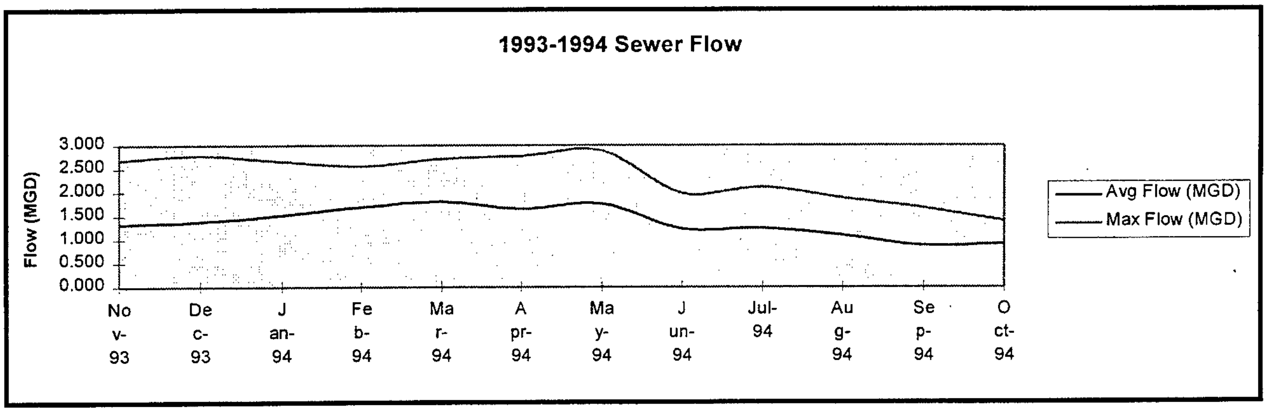


Figure 3B: Cadmium Concentration Chart



Month	Avg Flow (MGD)	Max Flow (MGD)
Nov-93	1.328	2.685
Dec-93	1.390	2.781
Jan-94	1.523	2.659
Feb-94	1.695	2.557
Mar-94	1.805	2.718
Apr-94	1.664	2.772
May-94	1.765	2.886
Jun-94	1.236	1.988
Jul-94	1.255	2.109
Aug-94	1.104	1.885
Sep-94	0.889	1.678
Oct-94	0.920	1.411
	Annual Average: 1.381	Annual Maximum: 2.886

Figure 4. Sewer Flow Data

Case 2: Based on the same assumptions as Case 1, this scenario assumes that six planes are washed under the same average conditions. Again, the loading to the sanitary sewer (0.23 pounds per day) is well below the permit limit of 0.366 pound per day. Since this case involves a number of aircraft, the use of average wastewater cadmium values is more appropriate than in scenarios involving a single aircraft. The bottom line for cases 1 and 2 is that under normal, routine conditions, there should be no danger of exceeding effluent limitations for cadmium.

Case 3: This scenario uses the "worst case" results for cadmium in the compressor wastewater, based on the highest wash water and rinse water concentrations from the AL/OEM study. These results represent the highest values measured for cadmium in C-130 compressor wash waters, including sampling performed by Pope AFB and by Little Rock AFB personnel. The concentrations are 16 times higher than the highest reading obtained during the Little Rock study, where samples of the wastewater were taken every few minutes for the duration of compressor washes on all four engines of a C-130. One additional note on this scenario is that we assume that this highest sample reading is maintained throughout the wash process, an assumption that is invalid based on results from the AL/OEM study and the Little Rock AFB study (Figure 5).

	Sample Number	Total Cadmium (mg/L)	TCLP Cadmium (mg/L)
Engine One and Three	3	1	0.26
	4	3.3	2.3
	5	4.4	3.2
	6	2.2	1.2
	7	5	3
	8	3.9	3
	9	1.4	0.89
	10	0.32	0.17
	11	1.1	0.64
Engine Two and Four	12	3.8	3
	13	0.23	0.14
	14	2.3	1.5
	15	5.1	4.1
	16	0.52	0.35
	17	0.36	0.23
	18	1.7	1.2
	19	2.1	1.2
	20	0.33	0.21
	21	0.18	0.14
	22	1.3	0.79
	23	1	0.83
	24	0.39	0.26
	25	0.18	0.092
	26	1	0.65
	27	0.64	0.47
	Averages	1.80	1.22

Figure 5. Little Rock C-130 Engine Compressor Wash Testing Results

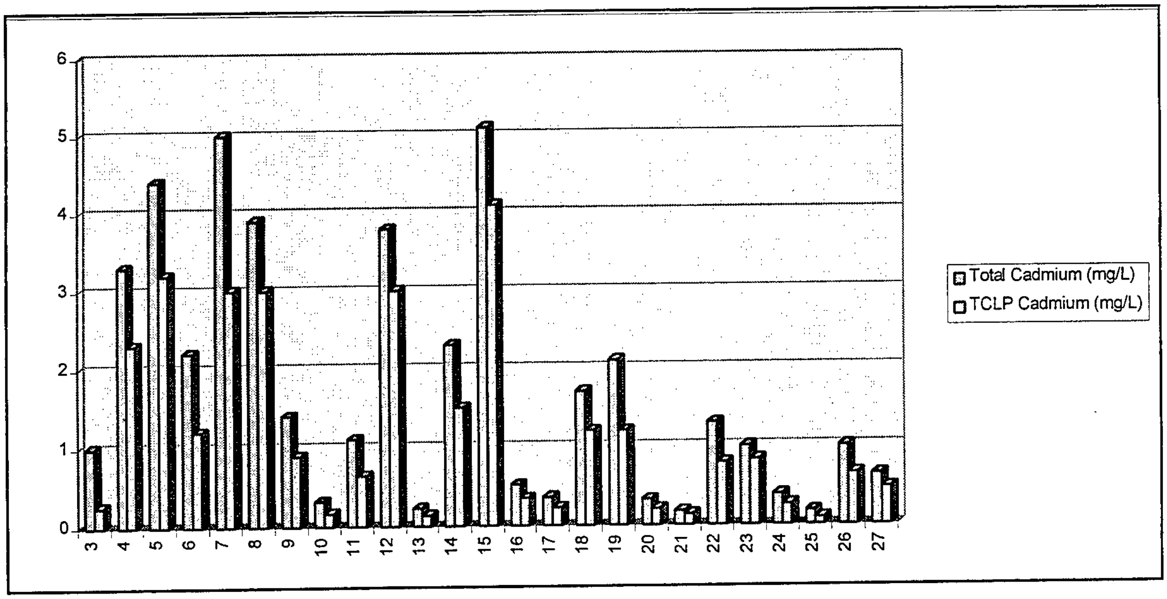


Figure 6. Little Rock C-130 Engine Compressor Wash Testing Results Chart

Using this high value, and a maximum value of 30 milligrams per liter for the rinse water, each aircraft would introduce 0.1 pounds (45.4 grams) of cadmium to the sanitary sewer. By comparison, the Little Rock AFB study predicts less than 2.7 grams of cadmium generated during the compressor wash of an aircraft's four engines. With average sewer flow and cadmium levels in this case, the loading at the compliance monitoring point would not exceed 0.15 pounds per day of cadmium. This is less than one-half the permit limit of 0.366 pounds per day.

Case 4: This scenario is identical to Case 3, except two aircraft are washed. Assuming both aircraft have "worst case" cadmium levels, the loading at the compliance monitoring point would still be less than the permit limit at 0.25 pounds per day.

Case 5: Case 5 takes the worst case wastewater conditions from Cases 3 and 4, and introduces them into the system with the highest cadmium levels detected through compliance sampling at Little Rock AFB (January 1993). The January 1993 compliance sample showed 0.0098 mg/L of cadmium with a flow of 1.9 MGD, for a loading of 0.16 pounds per day. One note of caution with this scenario is that we have compliance data since 1992 only, so this maximum is based on a limited number of sampling events. Data from prior to this date, however, may also be suspect since the base has undergone mission-related changes in the last few years. The January 1993 reading was a combination of the highest compliance sample cadmium level (over twice as high as any other reading) and abnormally high sewer flow (Figure 3). Since it appears to be abnormal based on other compliance data, it is likely a good representation of the high range for cadmium loading from the base. Using these high conditions for both compressor wash wastewater and base sewer cadmium, the model shows that cadmium at the compliance monitoring point would be 0.26 pounds per day. Two aircraft washed under these conditions would result in a loading of 0.3618, slightly below the limit of 0.366 pounds per day.

Case 6: This situation combines the average cadmium levels used in earlier scenarios with the high sewer cadmium levels. With a single aircraft, the loading at the compliance monitoring location would be 0.19 pounds per day. With three and five aircraft washes per day, the loading is still well below the permitted amount at 0.25 and 0.31 pounds per day, respectively.

Case 7: This case and the following cases attempt to correct for the cadmium that remains in the collection system and pretreatment devices. This case takes the worst case compressor wastewater and base sewer cadmium conditions and assumes that half the cadmium introduced through the compressor wash operation is entrained. Four aircraft can be washed without exceeding the pretreatment limit for cadmium. This model cannot predict what portion of the cadmium that is not immediately released to the downstream reaches of the sewer system may be released at a later time. While the oil water separator at Facility 228 and the lift station at Facility 270 may collect cadmium, particularly cadmium associated with solids, subsequent high flows due to fuselage washing or infiltration following a large rainfall event may resuspend some of the trapped cadmium. We do not attempt to predict the behavior of the cadmium under these conditions, or the effects of released cadmium on loading at the compliance monitoring point at times other than immediately following compressor washes. Cases 7 through 11 attempt to present a more accurate picture of what levels of cadmium to expect at the base outfall, but should not be used for planning purposes until we have additional data to quantify these concerns.

The trapped cadmium is a legitimate concern, and bringing the compressor wash operations to the washrack will require increased attention to the oil water separator and the lift station. Periodic maintenance and cleaning of these facilities should be planned for, and solid will need to be analyzed for hazardous characteristics prior to disposal.

Case 8: This scenario involves average wastewater concentrations with high base sewer cadmium loading. Again, as in Case 7, we assume half the cadmium will be trapped. Effluent levels even with five aircraft washed per day remain well below the pretreatment limit for cadmium.

Case 9: This case uses the highest levels from aircraft with average sewer loading, with retention of half the cadmium in the system. Results are similar to those from Case 8.

Case 10: Here we estimate the effects of worst case aircraft wastewater, with reasonable assumptions for varied cadmium loading in the sewer. We assume higher than average flow (1.5 MGD) and a cadmium concentration slightly higher than any of the previous compliance sample results. With half the cadmium trapped, loading from two aircraft do not approach the permit limit for cadmium.

Case 11: Results from the Little Rock AFB study suggest that about two-thirds of the cadmium from compressor washes is present in the dissolved form. Based on this, we assume under this scenario that 20% of the cadmium is retained in the pretreatment devices. Other conditions are the same as in Case 10. With the worst case for aircraft wastewater, abnormal but conceivable cadmium loading in the sewer, and a 20% retention of cadmium, three aircraft would reach the permit limit of 0.366 pounds per day. Based on this scenario, even with the conservative nature of the assumptions, we would recommend that the base restrict compressor wash operations to two aircraft per day. Additional wastewater characterization studies as part of Phase III of this study and other work being performed for HQ ACC may eventually show that more aircraft may be washed. In the meanwhile it would be prudent to limit compressor washes.

Conclusions and Recommendations

Based on the results of the mass balance modeling, there would be a very low risk of exceeding the pretreatment limit for cadmium under any conditions if no more than two aircraft per day have compressor wash operations performed on them. The model is conservative in that it assumes all of the cadmium generated during the compressor washes flows unimpeded off base, and is also conservative in using the AL/OEM data for worst case in the amount of cadmium generated per wash. Actual cadmium levels at the compliance monitoring location are likely to be much less than the predicted values.

Phase I: Mass Balance Exercise for Nickel

Scope

While the primary concern of this mass balance study and the other study phases is cadmium, the AL/OEM study did show levels of nickel in the compressor wash wastewater similar to those of cadmium. Rather than leaving compliance with the nickel pretreatment standard to chance, we have done a preliminary mass balance study to determine whether Little Rock AFB can expect problems with nickel from bringing the compressor wash operation indoors. This preliminary study was performed using limited data from the AL/OEM study and compliance monitoring data from Little Rock AFB.

Methods

We used the same spreadsheet model that we used for cadmium to model nickel. Of four samples analyzed for total nickel in the AL/OEM study, the nickel levels ranged from 6.2 to 33 mg/L, with an average of 20 mg/L. We used the 33 mg/L value to model the expected concentration from compressor wash operations. Table 2 shows the modeled scenario.

TABLE 2. DAILY NICKEL LOADING TO SANITARY SEWER

# Aircraft Washed	Washwater Ni Conc. (mg/L)	Volume of Washwater (gal)	Rinsewater Ni Conc. (mg/L)	Volume of Rinsewater (gal)	**Ni loading fr. operation (lbs/day)**	Ni conc. in sewer (mg/L)	sewer discharge (gal/day)	**sewer Ni loading (lbs/day)**	**TOTAL Ni load (lbs/day)**
Highest nickel concentrations from AL/OEM study, worst case base effluent data									
1	33	35	33	5	**0.0440**	0.06	1961000	**0.9813**	**1.0253**
5	33	35	33	5	**0.2202**	0.06	1961000	**0.9813**	**1.2015**
Highest nickel concentrations from AL/OEM study, current worst case base effluent data									
1	33	35	33	5	**0.0440**	0.01	1961000	**0.1635**	**0.2076**
2	33	35	33	5	**0.0881**	0.01	1961000	**0.1635**	**0.2516**
5	33	35	33	5	**0.2202**	0.01	1960000	**0.1635**	**0.3836**

Results and Discussion

The modeled case uses two separate values for background nickel levels in the base sewer system. Two compliance samples in 1993 approached the permit limit of 1.032 pounds per day, but we feel the results are not representative of current conditions in the base sewer system. Monthly monitoring results for nickel (Table 3, Figures 4 & 5) since 1992 show four distinct trends. Up to July 1992, concentrations of nickel were consistently around 0.02 mg/L. In August and September 1992, nickel was 0.01 mg/L. From October 1992 to March 1993, monthly concentrations were 0.06 mg/L (this is when the two highest compliance samples were taken; both accompanied exceptionally high sewage discharge days). From April 1993 to present, concentrations have consistently been 0.01 mg/L, with the exception of July 1994 when the concentrations were half that. This suggests that the concentrations used to calculate the mass of nickel at the compliance monitoring point are at or below the method detection limit for nickel for the laboratory analyzing the samples, and the only changes in nickel loading can be attributed to flow variations and changes in the method detection limit. The changes in the method detection limit are likely due either to a change in analytical method or a change in analytical laboratories. The base should verify that this is the case.

Nickel concentrations in the base sanitary sewer can therefore be estimated reasonably by using compliance data from April 1993 to the present. Under these conditions, assuming highest measured nickel concentrations in wash water and no retention in the collection system, there should be no concerns about exceeding the pretreatment limit for nickel for any conceivable number of compressor washes.

TABLE 3. NICKEL CONCENTRATIONS

Date	Ni Load (lbs/day)	Flow (MGD)	Nickel (mg/L)
Jan-92	0.24	1.425	0.0202
Feb-92	0.19	1.171	0.0195
Mar-92	0.45	2.713	0.0199
Apr-92	0.21	1.242	0.0203
May-92	0.15	0.88	0.0204
Jun-92	0.24	1.464	0.0197
Jul-92	0.17	1.041	0.0196
Aug-92	0.1	1.243	0.0096
Sep-92	0.06	0.746	0.0096
Oct-92	0.36	0.718	0.0601
Nov-92	0.57	1.135	0.0602
Dec-92	0.49	0.989	0.0594
Jan-93	0.98	1.961	0.0599
Feb-93	0.55	1.104	0.0597
Mar-93	0.96	1.923	0.0599
Apr-93	0.13	1.603	0.0097
May-93	0.16	1.958	0.0098
Jun-93	0.09	1.078	0.0100
Jul-93	0.07	0.91	0.0092
Aug-93	0.14	1.653	0.0102
Sep-93	0.067	0.798	0.0101
Oct-93	0.06	0.746	0.0096
Nov-93	0.12	1.49	0.0097
Dec-93	0.13	1.506	0.0104
Jan-94	0.07	0.893	0.0094
Feb-94	0.11	1.299	0.0102
Mar-94	0.17	2.11	0.0097
Apr-94	0.23	2.786	0.0099
May-94	0.2	1.988	0.0121
Jun-94	0.08	0.955	0.0100
Jul-94	0.0917	1.885	0.0058
Aug-94	0.1572	1.885	0.0100
Sep-94	0.093	1.115	0.0100
Ni avg, Apr 93 - present:	0.1205	1.4810	0.0098
Ni avg, Jan 92 - Mar 93:	0.3813	1.3170	0.0345
Total Overall Average:	0.239058	1.406455	0.0210

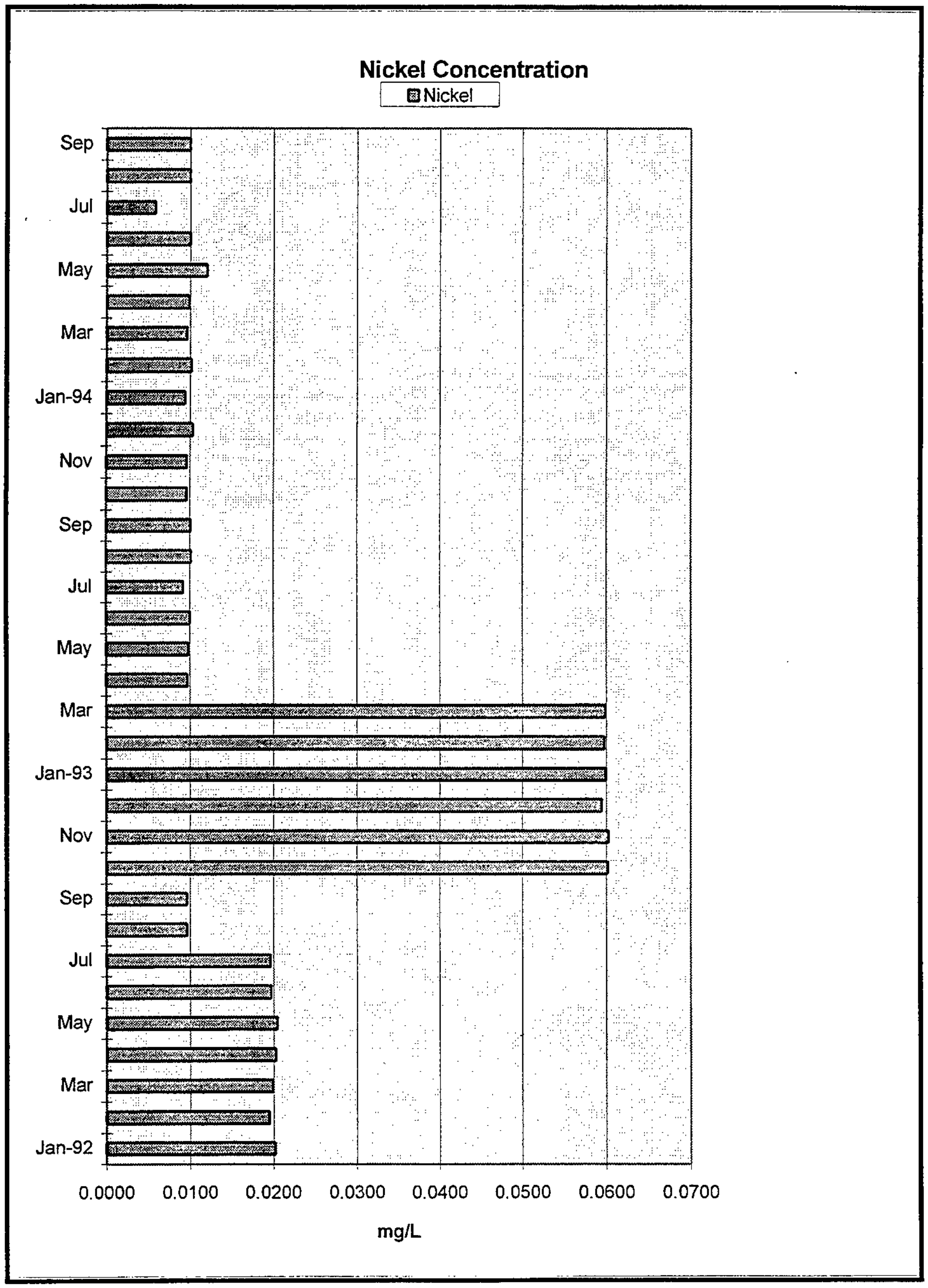


Figure 7. Nickel concentration

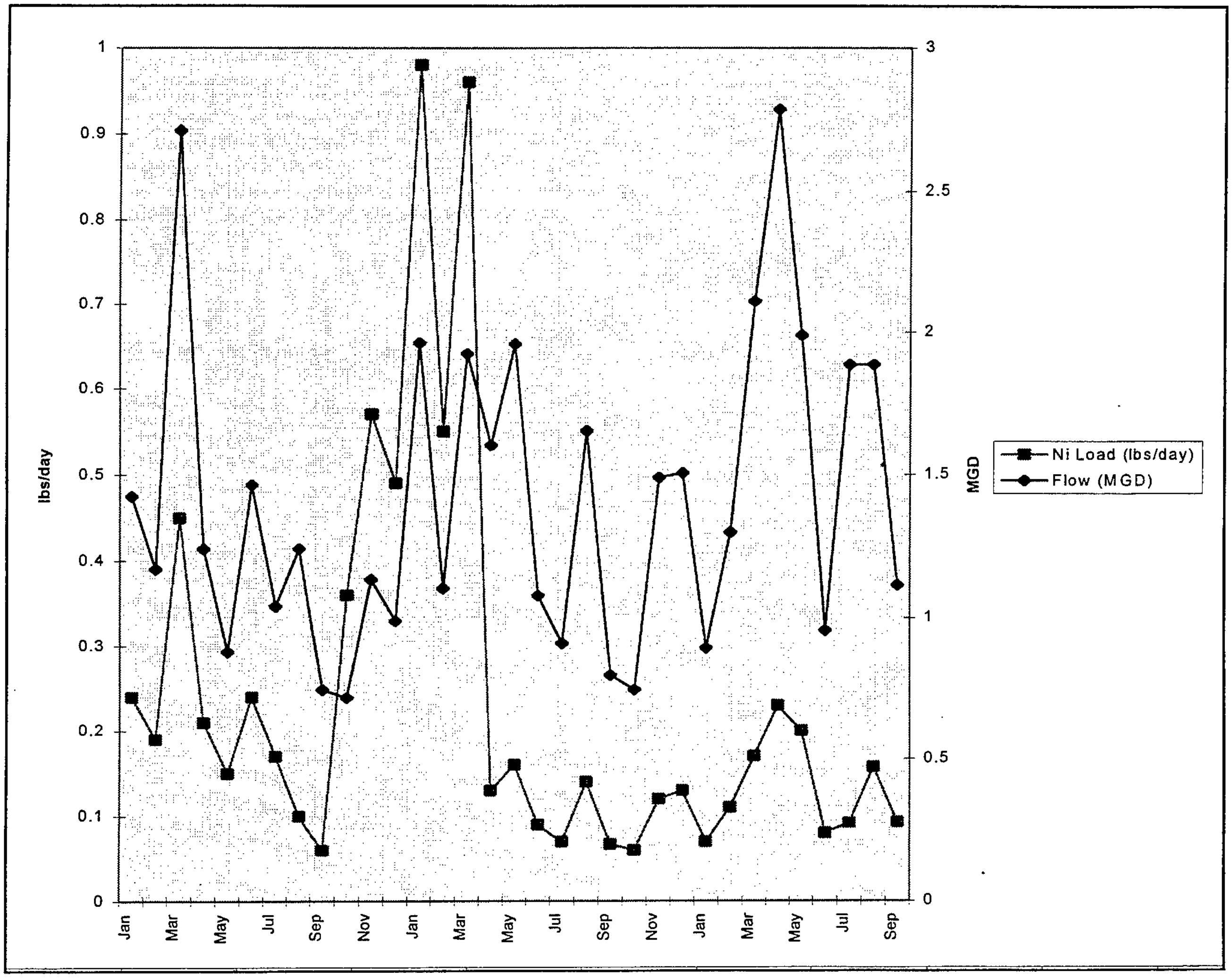


Figure 8: Nickel Load and Flow Result Chart

Conclusions and Recommendations

The factor that limits the number of allowable engine compressor washes at the Facility 228 washrack will be cadmium, rather than nickel. With current base wastewater concentrations near the detection limit for nickel (0.01 mg/L), the minimal amounts added through compressor washing will not approach the pretreatment limit at any sewer flow rate. The base should consider that nickel as well as cadmium will be present in solids that collect in the oil/water separator and lift station, and manage these wastes accordingly.

Phase II: Site Inspection and Tracer Study

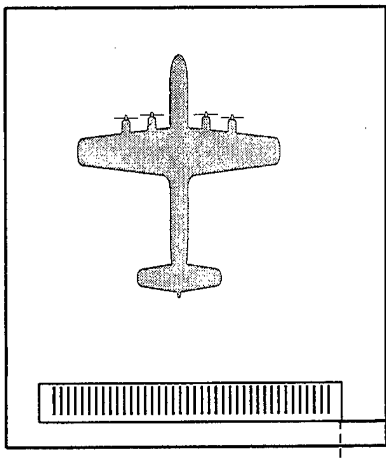
Scope

Phase I of this study was a compilation of existing knowledge on C-130 engine compressor washes and used this information to predict loading of cadmium to the sanitary sewer system. We did not attempt in Phase I to characterize the behavior of the waste upon entering the sewer system. Phase II attempted to address some of these additional concerns prior to introducing actual compressor wash waste to the sanitary sewer system. Between the wash rack at Facility 228 and the compliance monitoring station, there are several miles of sewer line, sewage input from the rest of Little Rock AFB, and two devices that will have a significant effect on how much cadmium will reach the compliance monitoring point and over what period of time it will get there. The first device is a 200 gallon oil water separator in the sanitary sewer line just north of Facility 228, which will receive wastewater from the washrack. The second is a 15,000 gallon sewage lift station that receives wastewater from the entire flightline area and pumps it to the sewage collection system for the rest of the base, after which gravity flow takes the sewage to the Jacksonville Treatment Works (see schematic diagram, Figure 6).

We know that much of the cadmium generated by compressor washes is in the suspended form, and that some of the dissolved cadmium will react with other components of the wastewater and either precipitate out or otherwise become associated with solids in the sewer system. Since the volume of wastewater generated during each compressor wash is less than the volume of the oil water separator and much less than that of the lift station wet well, there will be a delay in the compressor wash wastewater reaching the main base sewer system. Predicting the behavior of cadmium in this situation is impossible with the available data, and probably even with all the data we can ever hope to collect. Nevertheless, the site inspection and tracer study conducted as Phase II of this study answered some basic questions that help to understand the impact of this additional waste load on the base sewer system, and allowed us to plan for the actual indoor compressor wash operational testing scheduled as Phase III of this study.

Methods

In order to determine how the oil water separator and lift station affect the flow of wastewater components from the washrack to the terminus of the base sewer system, we designed a study to introduce a tracer at the washrack and perform quantitative, real time monitoring of the sewer system at various points downstream from the washrack and pretreatment devices.



O/W Separator Cd-Bottoms	
Before	40.5 mg/L
During	43.2 mg/L

O/W Separtor Effluent		
	Cd-Total	Cd-Dissolved
Before	0.125	0.113
During	0.046	0.084
After	0.323	0.227

Before Lift Station (composite samples)		
Time	Cd-Total	Cd-Dissolved
1253-2101	0.107	0.044

Wash Rack Drain (composite sample)		
Time	Cd-Total	Cd-Dissolved
1510-1655	0.152	0.092

Lift Station Cd-Total	
Before	<0.001 mg/L
After	0.027 mg/L

End of Force Main (composite sample)		
Time	Cd-Total	Cd-Dissolved
1900-0400	0.23	0.011

Gym In mg/L	
Time	Cd
1301	0.011
1401	0.057
1501	N/A
1601	0.012
1701	0.009
1801	0.01
1901	0.016
2001	0.008
2101	0.007
2201	0.021
2301	0.007
1	0.008
101	0.003
201	0.005
301	0.019
401	0.053
501	0.036
601	0.01
701	0.006
801	0.003
901	0.004
1001	0.006

Golf Course In mg/L	
Time	Cd
1916	0.001
2016	0.004
2116	0.003
2216	0.009
2316	0.002
16	0.001
116	0.001
216	0.001
316	N/A
416	0.006
516	N/A
616	0.002
716	0.001
816	0.001
916	0.001
1016	0.001
1116	0.002

Compliance Monitoring Point (composite samples)			
Day	Cd Total	Flow	Pounds/Day
Mon	0.004	1.75	0.058
Tue	0.004	1.6	0.053
Wed	0.004	1.55	0.052
Thu	0.004	1.71	0.057
Fri	0.004	1.78	0.059

Figure 9: Compressor Wastewater Flow from Washrack Facility 228

Tracer Study, Day One

We planned to introduce a calcium chloride solution, 500 parts per million as calcium, to the washrack and monitor at and downstream from the oil water separator and lift station. We chose calcium chloride because it is soluble, non-toxic, and measurable with portable instrumentation (ion specific probe for calcium). Calcium is a divalent metal, as is cadmium. Additionally, Little Rock AFB drinking water and sewer water are relatively low (less than 10 parts per million) in calcium. This aids in detecting calcium solutions added to the sewer system.

At the inbriefing on 19 December 94 at Little Rock AFB, base environmental personnel brought up the fact that the Air National Guard unit at the installation would be performing engine compressor washes at a separate facility, independently from the ACC unit operations at Facility 228. There was concern that the effects of simultaneous washes at the two facilities might not be adequately accounted for by a test at the 228 washrack alone. Since wastewater from both facilities goes through the lift station at Facility 270, base personnel devised a test where we would introduce simulated wastewater to the lift station wet well and measure the effects downstream in the wastewater collection system. We initiated this study the afternoon of 19 December 94.

We prepared a 500 part per million calcium (approximate) solution by mixing 1.5 pounds of reagent grade calcium chloride in 300 gallons of tap water, contained in six 55-gallon, unused steel drums. We preset three automatic samplers to collect period samples before and after introduction of the simulated wastewater. One sampler was in the sewer line immediately upstream from the lift station to monitor calcium concentrations of wastewater entering the lift station. Locations of all samplers are illustrated in Figure 6. A second sampler was in the sewer line at the manhole where the line from the lift station and flightline area enters the main base collection system. The third sampler was at a location by the golf course, near the base boundary, downstream from the last tie-in from base facilities. This third location was at a point where all wastewater from the base had to pass prior to leaving the installation. We initially planned to place a fourth sampler at the compliance monitoring point, about two miles downstream from our third sampler, but decided against this for three reasons:

(1) the wastewater from the proposed fourth location would have been identical to that of the third location (straight line to the compliance monitoring station with no other lines tied in between the two points), except for the timing of the calcium reaching that point and possible dilution effects due to infiltration over the last two miles of sewer line;

(2) the 500 part per million calcium solution added at Facility 270 would be so diluted that far downstream that it might not be detectable with our instrumentation (our original plan was to test in the flightline area only); and

(3) time constraints posed by the need to set up the samplers, prepare and introduce the simulated waste, set up the laboratory, and analyze samples from both days (we had proposed doing only one day of tracer studies and using the day of 19 December to set up for the study to be run on 20 December. Additionally, samplers set up that far downstream from the lift station would have to be run overnight to allow the simulated wastewater to reach that point, requiring additional analyses the next day while performing the originally planned study).

We set Sampler 1 (background) to sample every half hour for two hours, a time period we determined adequate to ensure that the lift station would discharge enough of the simulated wastewater to create a slug of calcium downstream in the sewer system. We set Sampler 2 to collect samples every half hour for six hours, after which we calculated the majority of the calcium would have passed this near-downstream point. We collected samples from both of these samplers in the evening of 19 December 94. We set Sampler 3 to collect every one hour for 12 hours. We collected samples from Sampler 3 on 20 December 94.

Results and Discussion

Despite our best efforts, this was not a highly successful test. Background results from Sampler 1 showed results ranging from six to nine parts per million calcium, indicating that there were no other sources of calcium entering the system that would have confounded our results. Sampler 2 showed only background levels of calcium as well. The cyclic action of the wet well, discharging its contents on a periodic basis when water levels reached a certain point, combined with the cyclic action of the sampler, sampling only every half hour, caused the sampler to miss the slug of calcium completely. The flow at the point of Sampler 2 was fast and there was no pooling to hold discharge from the lift station for any length of time. In retrospect, we should have chosen a sampling location several hundred yards downstream from the Sampler 2 site or at least constructed a sandbag dam at the selected location to retain flow for a loner period of time. This did not occur to us during the short time in which we prepared for this additional study. Sampler 3 did not save the study. The battery shorted out after taking only three samples, all of which were before the calcium slug had reached this distant location. It is unclear whether the calcium slug would have been detectable after mixing with other base sewage, but that is irrelevant since the sampler did not operate properly.

Tracer Study, Day Two

Our plan for the second day of tracer studies was as originally designed. We set an automatic sampler at the manhole immediately downstream from the oil water separator at Facility 228, and an automatic sampler further downstream immediately upstream from the lift station. We introduced one half pound of calcium chloride to the slot drain at the washrack at Facility 228 (drain hole plugged), filled the slot drain with approximately 200 gallons of tap water, activated the samplers, and opened the drain hole to allow the simulated wastewater to enter the sewer. At the same time, a crew from Little Rock AFB was washing the fuselage of a C-130 aircraft, with their wash and rinse water going to the same drain. This would approximate real life, since both operations would be conducted in the same hangar , often separated by little time. We added four fluorescent dye tablets at the drain to time the flow of wastewater through the oil water separator visually. Although the oil water separator is about 200 feet from the washrack drain, after one hour there was still no evidence of increased flow or dye at the separator. We began to look for other potential exits for the dye and hundreds of gallons of wastewater. Other manholes in the area showed no lines connected to Facility 228. We found the dyed water beneath an open grate near Facility 228 that led to the storm drainage system for the flightline.

Base personnel traced the flow to the flightline ditch, and initiated corrective measures immediately to reroute the washrack flow to the oil water separator and the sanitary sewer. Corrective measures were not completed in time to reattempt the tracer study, so it was canceled. Base personnel were uncertain how long the washrack had been routed to the storm drainage system.

Site Inspection and Summary of Findings

In addition to the tracer studies, in the process of setting up the studies we made some observations regarding the Little Rock AFB sewage collection system.

Infiltration. The base is currently performing a sewer inspection and infiltration study. This is a key for the base in maintaining control of wastewater quality and quantity. Infiltration is a problem recognized by the base, and the seriousness of this problem is shown by billable flow rates which often more than double following significant rainfall, and noticeable evidence of sewer overflows at least three locations near the base boundary. The dry well of the oil water separator at Facility 228 is full of water, and seepage from this enters the sanitary sewer downstream from the separator. The current base study should help to reduce significantly infiltration problems. While infiltration will not directly affect the compressor wash operations, the increased flows may cause levels of cadmium and nickel to exceed permit limits if laboratories have elevated detection limits (such as for nickel in the past).

Security. The off base compliance monitoring station is secured by a seven foot chain link fence topped by barbed wire. The sewer line off base passes through two miles of industrial and commercial properties, and is not secure. Additionally, the sewer line between the golf course and the base boundary is not secured, as there is no fence along the base boundary here. To prevent unauthorized access to the base sewer line in these locations, we would recommend as a minimum installing locking manhole covers in these areas. It would also be a good idea to install a security fence along the base boundary, or at least a gate on the access road to discourage those in vehicles from entering along the route of the sewer.

We understand that video footage of the sewer line through the industrial area showed no illicit connections to the base sewer. Based on our own flow measurements on 20 December 94, flows at the compliance monitoring station and near the base boundary were very similar. There are no guarantees that future construction or modification of existing industry in the area will not connect to the base sewer line. For this reason primarily, we would recommend the base install a compliance monitoring station on base property near the site of the existing flume. This would ensure that only base inputs to the sewer system are charged to the base, and reduce the possibility of violations caused by illicit disposal of wastes by commercial or private parties.

Slug Flows. The base environmental office requested that we evaluate the possibility of slug flows of cadmium from the compressor wash operations causing erroneous high readings during the composite sampling for compliance purposes. Stated otherwise, is there a possibility that a combination of discharge rates and cadmium concentrations could overestimate the loading of cadmium from base sewer flow? One piece of information we had hoped to obtain to help answer this question was the time required for cadmium in solution to travel from the wash rack to the compliance monitoring point. Although our tracer study did not provide this information, enough information exists to make a reasonable determination on this issue.

The oil water separator at Facility 228 and the lift station wet well at Facility 270 will serve to equalize flow from the wash rack at Facility 228. If we assume that compressor washes are limited to two per day, and the compressor wash immediately follows a fuselage wash, then we can estimate that the cadmium from the first compressor wash will be completely flushed through the 200 gallon oil water separator with the water from the second aircraft fuselage wash. We should also assume for safety that washes will be performed on consecutive days, and that the compressor wash waste from the second wash one day will be flushed from the oil water separator by the fuselage wash water from first wash the next day. Thus, we can assume two slugs of cadmium from the oil water separator each day the operations are performed.

Using an estimated 0.1 pounds of cadmium per aircraft (worst case), approximately 0.2 pounds would leave the oil water separator in two daily slugs. We will also assume here that three hours separates the two slugs, and that it will take each slug one hour to reach the lift station at Facility 270. We will further assume for this situation that operations will take place in the morning, during highest wastewater flow. When the first slug reaches the lift station, we will assume that the entire 0.1 pounds of cadmium goes into the wet well, mixes with 10,000 gallons of other wastewater, and is completely emptied to the downstream portion of the collection system before the second slug arrives three hours later. Assuming other sources of cadmium are negligible, and the discharge from the lift station represents 40% of the total flow and is completely mixed with the wastewater from other sources.

Phase III: Evaluation of Actual Indoor Compressor Wash

Scope

We performed the field work for the Phase 3 effort the week of 23 Jan 95. Our sampling focused on two separate issues: the characteristics of the wastewater generated from C-130 compressor washing, and the implications of introducing this wastestream into the base sanitary sewer via the Building 228 wash rack. Following are our preliminary findings and recommendations for conducting compressor wash operations to assist you until we complete our evaluation and issue a technical report.

Methods

A single C-130 (tail number 793) was towed to the indoor washrack at Building 228, where base personnel washed the exterior of the airplane, followed by a engine compressor washes. We collected two samples of washwater from the fuselage wash, one of which was washwater from wing washing, and the other was from washing the engine exhaust area. We collected samples from each of the four engine washes. On three engines, we collected washwater and rinsewater separately. This was accomplished by placing polyethylene sheeting over a ten-foot square two-by-four frame, placing this assembly under the engine in a position to collect as much wastewater as possible, and pulling wash and rinse samples from the assembly when each operation was completed. Plastic sheeting was changed between each sample collection, and the remaining water was poured on the washrack floor beneath the aircraft. On the fourth engine, we collected samples from a "baffle box" device fabricated by Little Rock AFB to collect wastewater from C-130 engine compressor washes. The baffle box collected wastewater from the engine exhaust port (back of engine), and water that did not exit the exhaust port was collected separately from the engine cowling. Rather than discrete wash and rinse samples, the samples from this engine were composites of wash and rinse waters.

In addition to the aircraft wastewater samples, we collected samples from the sanitary sewer system immediately following the wash operations to evaluate the behavior of metals in the base sanitary sewer down to the base boundary. This consisted of various grab and composite samples,

All samples were shipped to the Armstrong Laboratory Analytical Services Division (AL/OEA) for analysis.

Field quality assurance/quality control samples for this effort included equipment blanks (including the stainless steel pitcher used for scooping samples from the plastic sheeting, for the plastic sheeting itself, and for the automatic samplers), blanks of the cleaning solution and water used to perform the compressor washes, a reagent water blank, and duplicate samples. Matrix spike samples for all parameters were supplied by AL/OEA.

Wastewater Characterization Results

The metals results from the wastewater characterization are consistent with those from the AL/OEM study performed at Little Rock AFB in 1994 (AL/OE-TR-95-0010). We sampled each engine on a single C-130 this time, and our average concentration for total cadmium during the compressor wash was 21.5 mg/L (24.3 mg/L in 1994) and for the rinse, 12.9 mg/L (11.1 mg/L in 1994). Nickel concentrations were slightly lower than indicated in the 1994 study. Our findings support the use of average concentrations for the mass balance model we presented to the base in December 1994. We also sampled water from fuselage washing and found some cadmium, primarily from the engine exhaust area (1.93 mg/L total, 0.4 mg/L TCLP). We cannot characterize the fuselage wash wastewater from the two samples collected, but we would suspect a composite from the entire aircraft would be similar to the result from wing washing (0.06 mg/L).

Sanitary Sewer Results

Our sampling of the sanitary sewer system consisted of various composite and grab samples from the wash rack drain, oil water separator, lift station, and points in the collection system including the compliance monitoring point off base. The following paragraphs summarize significant findings from each area.

a. Wash Rack Drain: We collected a composite sample over the entire period the compressor wash was going on. Only a small portion of the compressor wash water reaches the slot drain during the operation, due to the small volume of wastewater and the long distance over rough concrete to the drain. Most of the wastewater must be flushed into the drain by hosing down the hangar floor. Our sampling included this hose-down procedure. The cadmium concentration in the water actually entering the drain was 0.15 mg/L, and the nickel was 0.07 mg/L. Of note here is this level is much lower than the RCRA limit upon entering the sewer, without any deliberate dilution. While we had no way to meter the water used during the operation, it was probably less than 500 gallons combined for the compressor wash and floor washing. Using this estimated flow and our measured calculation, approximately 300 mg of cadmium entered the sewer system. Based on our measured cadmium concentrations and cleaning solutions used for the compressor wash operation, about 5000 mg of cadmium was present in the wastewater when it hit the floor. These are preliminary calculations based on quantity estimates of water used, but they do support the assumption that the concrete floor of the hangar reduces the amount of cadmium entering the sewer system.

b. Oil Water Separator: We sampled the bottom of the oil water separator to determine if cadmium is accumulating in sediments. We also sampled the water entering and exiting the separator before, during, and after the wash to estimate the behavior of cadmium in relation to suspended solids. Our results did not show conclusively what effect the separator has on cadmium in the wastewater, but did show two important things. First is that cadmium does accumulate in the sediments collected by the separator. There was not enough sediment to collect a solids sample, but we did collect liquid samples with substantial amounts of settled solids before and during the compressor wash. The laboratory digested the samples in acid to estimate total cadmium levels in the solid/liquid mix. Both samples had total cadmium levels above 40 mg/L, several times higher than samples from when the separator was cleaned prior to performing compressor washes in Building 228. Second, cadmium is exiting the oil water separator. Cadmium in the effluent from the separator prior to and after the compressor wash was two to three times higher than during the compressor wash, when higher flows diluted the wastestream. Most of the cadmium exiting the separator during low flow is in the dissolved form (70-91%), while cadmium entering the separator is more equally distributed between suspended and dissolved fractions (60% dissolved). Separator effluent during the operation (high flows) is similar to the influent (54% dissolved). While there are not enough data points to quantify a relationship, these data support the assumption that the separator does retain some of the suspended cadmium. The key factors for the oil water separator are maintenance to remove accumulated cadmium and caution in the amount of water flushed through the separator due to the potential for flushing out accumulated cadmium. The recommendations section will include our specific suggestions for operations until a pretreatment unit is put in place.

c. Lift Station: We originally anticipated the lift station (Facility 270) would have some effect on cadmium by offering another location for settling of solids. Inspection of the facility during this study indicated otherwise, as it is designed and operated to flush completely during each cycle. Turbulence generated during the pump cycle prevents accumulation of solids, and our sampling confirmed this. The volume of the lift station wet well does serve to equalize flow to some extent, which would help to minimize higher "slug" concentrations of cadmium further downstream. This is made less important, however, due to the volume of wastewater coming from the flightline area in relation to the total flow from the base. Assuming both pumps at the lift station are operating at design efficiency (500 gallons per minute at 88 feet of head), data from the week of 16 January suggest that around 40% of the base's wastewater originates from the flightline area. This serves to dilute wastewater from the wash rack prior to entering the gravity-flow portion of the collection system. On the other hand, there is less opportunity for further dilution once the water leaves the flightline area.

d. Collection System: After initiation of the compressor wash on 25 January, we took hourly samples from a manhole near the middle of the collection system (base gym), and also from a point near where the sewer leaves the base (golf course). No cadmium concentrations higher than 0.009 mg/L were detected at the golf course site, but several samples from the gym showed cadmium concentrations between 0.02 and 0.06 mg/L. At the gym site, two consecutive hourly samples showed the distinctive milky white characteristics of wash rack water, and had associated cadmium concentrations of 0.036 and 0.053 mg/L. Although these were diluted prior to leaving the base, the potential for these types of wastewater slugs to travel that far in the collection system during low flow periods exists. It should be noted that even if the highest concentration detected leaving the base (0.009 mg/L) were to be sustained for 24 hours, the cadmium loading under average flow conditions (1.5 million gallons per day) would remain below 0.2 pounds per day. It is imperative, however, for compliance with the Jacksonville permit that the base implement true flow proportional compliance sampling. This will also ensure that any such slugs will not be over-represented in calculating the 24-hour metals loading from the base.

e. Compliance Monitoring Point: The Little Rock Bioenvironmental Engineering team collected 24-hour composite samples each day during the week of 16 January, and all cadmium concentrations were below the detection limit of 0.004 mg/L. Loading based on these numbers and City of Jacksonville flow data from the sampling periods ranged from 0.052 to 0.059 pounds of cadmium per day, well below the permit level of 0.366 pounds per day or the anticipated revised permit limit of around 0.2 pounds per day. We analyzed the composite sample from 25 January for all metals evaluated during the study, and showed cadmium at 0.002 mg/L and nickel at less than 0.03 mg/L, confirming the base's results. Nickel loading was less than 0.4 pounds per day, about one third the allowable level.

Recommendations

a. Frequency of Washes: Based on information collected to date, it does not appear that levels of nickel and cadmium from compressor wash operations will affect compliance with the base pretreatment agreement. For the short term, the conditions observed during the study of January 1995 can be expected to be representative for further operations at the Building 228 wash rack. We cannot predict what the effects of high flow from several washes per day would be on cadmium detained in the concrete floor of the hangar or in the oil water separator sediment, so we are recommending that no more than two aircraft per day be washed (fuselage and compressor wash) at Building 228. As long as cadmium from other sources on the base remains at non-detectable levels, cadmium from two aircraft should not cause exceedances of the pretreatment agreement.

b. Oil Water Separator: Since this study showed cadmium accumulating in the oil water separator, we recommend that the separator be pumped out to remove solids at least monthly during the time the base conducts compressor washes at the facility. The solids will likely have to be managed as a hazardous waste.

c. ANG Operations: While we have not investigated the Air National Guard wash rack facilities, we can make the following general recommendations: prior to any compressor washing at ANG facilities, any pretreatment devices should be cleaned to remove any preexisting contaminated sediment or other waste. If base personnel determine, upon inspecting the wash rack, that the only source of cadmium to the sewer would be that from the aircraft wastewater, then one aircraft per day would not appreciably increase the loading of cadmium to the sewer. Ideally, no more than two aircraft per day should be washed on the installation, but it is unlikely that three would cause the base to approach the pretreatment agreement limit.

d. Monitoring: Little Rock's pretreatment agreement requires that any monitoring more frequent than required by the permit be reported to the city with normal reporting requirements. The base should determine whether sampling conducted in the collection system falls under this requirement, or if it's acceptable to submit all data collected. We would recommend sampling periodically to determine cadmium from other sources on base, and sampling periodically (perhaps monthly) below the oil water separator to ensure that accumulated sediments are not being flushed out in unacceptable quantities. We also recommend that the base collect samples from the golf course area after a long period of compressor washing (i.e., two to three months of operations) to determine if there are any changes in cadmium loading and behavior after the wash rack area presumably has approached more steady-state conditions. We do not recommend any additional sampling of compressor or fuselage wash wastewater .

e. Pretreatment: The results of this study suggest that the base may cautiously pursue compressor wash operations on C-130s without industrial wastewater pretreatment, and still maintain compliance with the existing pretreatment agreement with the City of Jacksonville. The Air Force guidance on C-130 engine compressor washing may change, however, as may the operational requirements of Little Rock AFB. With the uncertainties associated with current and potential discharges of heavy metals into the sanitary sewer system, it would be prudent for the base to investigate a pretreatment system to reduce metals loading from C-130 washing operations. The base should consider pretreatment alternatives available, particularly those presently being evaluated in studies being sponsored by HQ ACC/CEVCM for C-130 engine compressor wash wastewater. AL/OEBW can assist in determining which pretreatment system would be appropriate for Little Rock AFB.

Summary

Phase I. To investigate the implications of heavy metals from C-130 engine compressor washes on the compliance status of Little Rock AFB, AL/OEBW performed a three-phased study. Phase I was a mass balance exercise that looked at cadmium and nickel loading. Loading was estimated from sampling performed during compressor wash operations, and modeled using flow data from the Little Rock sanitary sewer system. We looked at several potential scenarios, varying the concentration of metals in the wastewater, numbers of aircraft washed, retention of metals in the washrack and oil water separator, and discharge rates in the sanitary sewer. Phase I indicated that based on the mass balance calculations, it was likely that some aircraft washing could be performed, without pretreatment, even under worst-case conditions.

Phase II. Phase II of the study was a field test of some of the assumptions of Phase I. We performed an inspection of the collection system, and attempted a tracer study to evaluate the behavior of metals introduced through the washrack at Facility 228. While several problems with the study prevented us from getting the definitive answers we were seeking, Phase II did identify a problem with the plumbing at Facility 228 that was fixed prior to implementing Phase III and helped us select sampling points and design a sampling strategy for Phase III.

Phase III. Phase III was an actual C-130 compressor wash at Facility 228, with monitoring of wastewater at the source, in the vicinity of Facility 228, and at critical points in the sanitary sewer system. The results validated the basic assumptions of Phase I and Phase II, suggesting that the base could conduct some C-130 compressor wash operations at the indoor wash rack, without pretreatment, and remain in compliance with the pretreatment agreement.

Recommendations

The combined results of the phased investigation led to our recommendations that the base could conduct compressor washes on up to two or three aircraft per day without pretreatment. We recommended that the base carefully monitor and maintain the oil water separator at Facility 228 as long as compressor washes would be conducted there, to ensure that non-compliance would not result from cadmium in the separator from past operations being released into the sanitary sewer system in subsequent operations, resulting in a slug of heavy metals that could cause a violation of pretreatment agreement limits. Additionally, we recommended that if compressor washes were to be conducted for a long time period, the base should consider an industrial wastewater pretreatment system for heavy metals generated from the operations.

REFERENCES

Evaluation of C-130 Compressor Washing Operations Health Assessment, Little Rock AFB, Arkansas, AL/OE-TR-950010